6/23/05
TD-05-029

Spike studies using Superconduting strands

Test set up

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This note describes the test set up and test procedures for measuring voltage spikes in superconducting strands. The different types of Nb_3Sn samples for the tests are also introduced.

1) <u>Introduction</u>

Magnets which are utilizing unstable Nb3Sn conductor were extensively studied at Fermilab. While energizing these magnets we observed many voltage spikes by monitoring two half coil segment voltages. Since the magnet coils are made of multi-strand cable it was not obvious whether the complexity of the cable or just the strand itself is responsible for the shape of the spikes. The main goal of testing strands is to try to identify the origin (strands or cable) of these voltage spikes.

2) <u>Hardware set up</u>

Critical current measurements of superconducting strands are performed at the Short Sample Test Facility (SSTF) at Fermilab. The measurement is accomplished, at constant magnetic field and temperature, by ramping up the current and monitoring the voltage in between voltage taps which are usually attached to both ends of the coil (sample). The voltage is zero until the current is high enough to turn the superconductor into the normal state. If the transition between superconducting to normal state is gradual and reversible means that the superconductor reached its critical current value. However, if it is abrupt (non-continuous) and not reversible it usually points toward premature quenching of the sample. These critical current measurements are performed at various external magnetic field values. The magnetic field direction is perpendicular to the strand and the sample is wound on a grooved cylindrical Ti-alloy barrel fig. 1 [1].

In order to measure voltage spikes on strands the Voltage Spike Detection System [2] (VSDS) developed by the Instrumentation & Control group of the Development & Test department of the Technical Division is planned to be used in parallel to the SSTF critical current readout system [3]. Three signals have to be provided to the VSDS: the current signal and the two voltage signals between the two half coils. The two half coil signals must be inductively balanced in order to be able to remove the common noise by bucking the two signals.

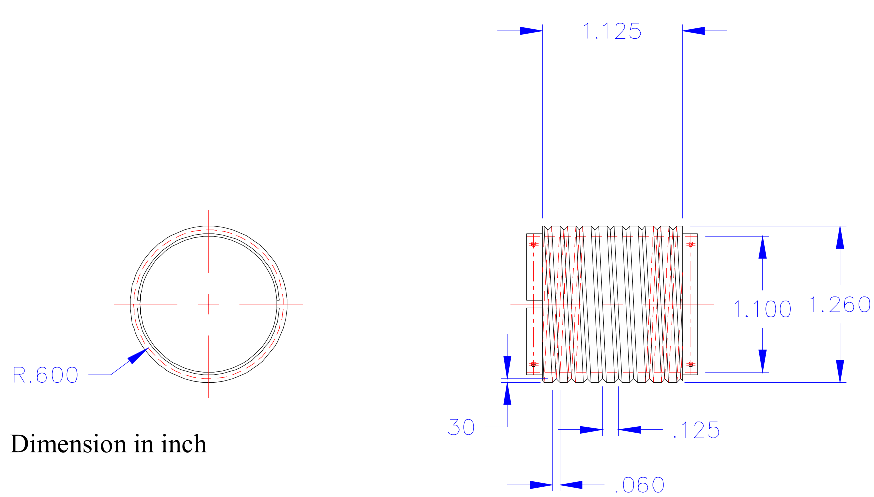


Fig.1 Strand sample holder

2.1) Current Signal

At the SSTF the two current supplies can provide a voltage signal proportional to the output current value. The maximum current for each power supply is 895 A and the voltage signal changes linearly with the current between -0.125V and 5V.

The two power supplies (the master and the slave) are connected in parallel. The slave power supply follows the current that is provided by the master. Since the difference in current between the two power supplies is negligible, the only signal coming from the master is sent to the VSDS.

2.2) Voltage taps and wiring

The goal is to install the voltage taps in a configuration that allows performing voltage spike measurement and standard current voltage measurement at the same time.

In fig. 2 a simplified electric schematic of the SSTF is shown. The probe that supports the sample holder has 6 pairs of twisted wires (permanently attached to the probe) so the maximum number of channels for measuring the voltages is six. These voltage tap wires are connected to a 12 pin connector located at the top of the probe. For standard current-voltage measurements only 3 pairs of wires are used as is shown in Fig. 3 [3]. In tab. 1 we collected all the wiring and connector pin assignment information.

For spike studies 2 spare wire pairs will be used for the two half coil signals as it is shown in fig. 4 and in tab.2.

2.3) Splitting the 12-pin connector voltage signals

The easiest way to access the V-tap signals is to make a break-out box and split the signals in the box, and then to connect each signal to several different connectors. For this purpose a 'connector' box has been built. Fig. 5 shows the schematics of the readout system after the box was introduced and Fig. 6 shows the electrical schematics of the 'connector' box itself.

All 6 signals have been completely duplicated for being sent to the standard critical current readout system (slow DAQ) and to a fast DAQ system recently introduced for quench detection and other studies [4]; moreover the 2 voltage signals coming from the 2 half coils have been hooked up to separate 8-pin connectors to be compatible with the VSDS system.

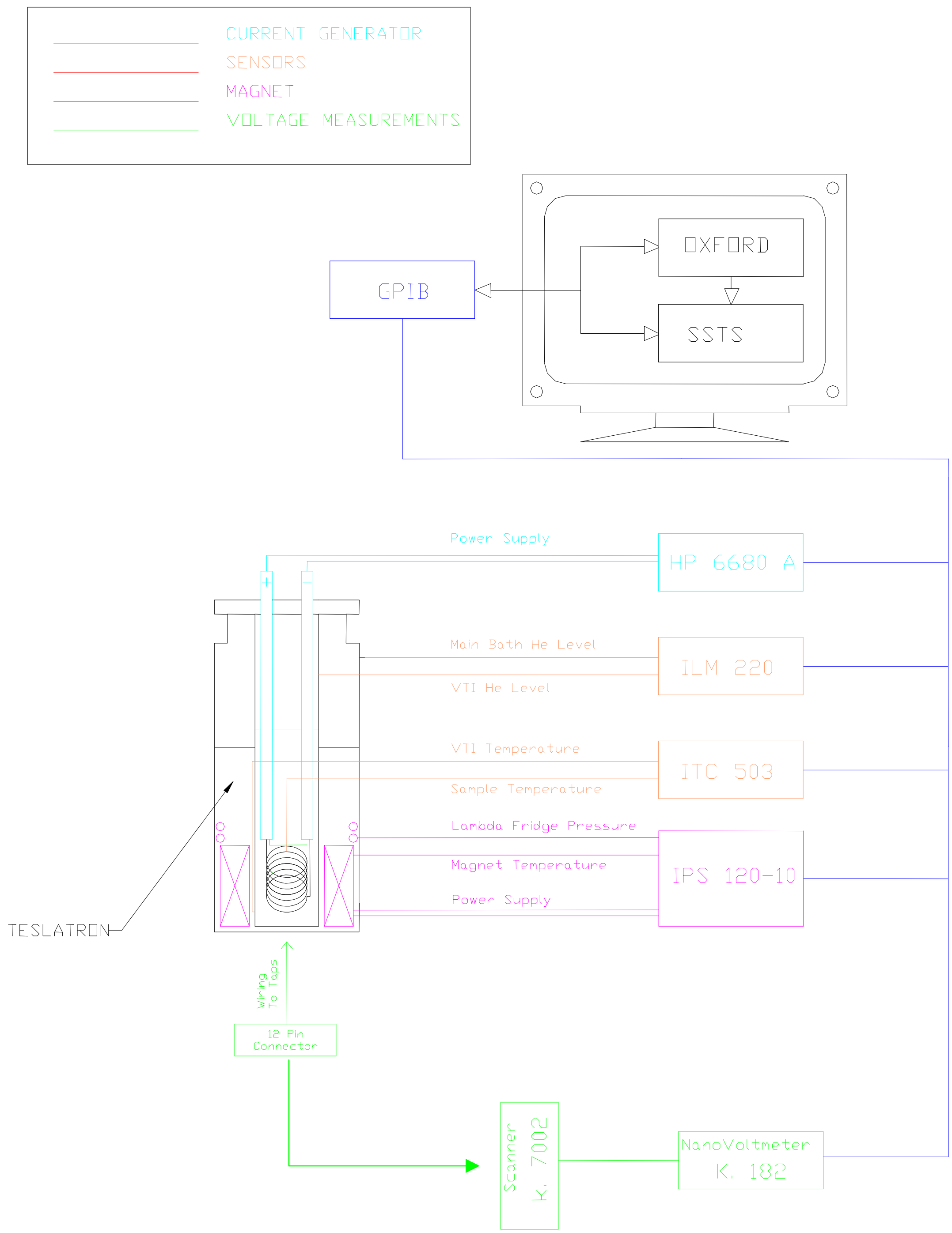


Fig.2 Simplified electric schematic of the SSTF

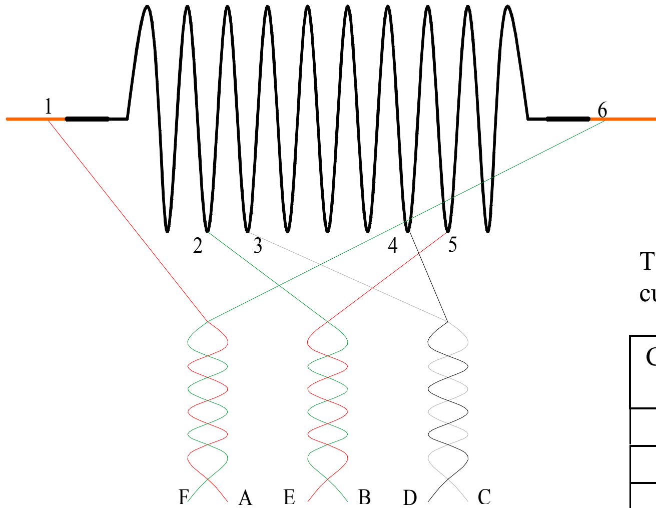


Fig.3 Taps and wiring configuration for standard current-voltage measurement

Tab.1 Taps and wiring configuration for standard current-voltage measurement.

CABLE'S WIRES	CONN. PINS	PROBE'S WIRES	TAPS LOCATION
RED	A	RED	1
GREEN	B	GREEN	2
BLUE	C	WHITE	3
BLACK	D	BLACK	4
BLACK	E	RED	5
BLACK	F	GREEN	6
YELLOW	G	WHITE	SPARE
BLACK	H	BLACK	SPARE
BROWN	J	RED	SPARE
BLACK	K	GREEN	SPARE
WHITE	L	WHITE	SPARE
BLACK	M	BLACK	SPARE

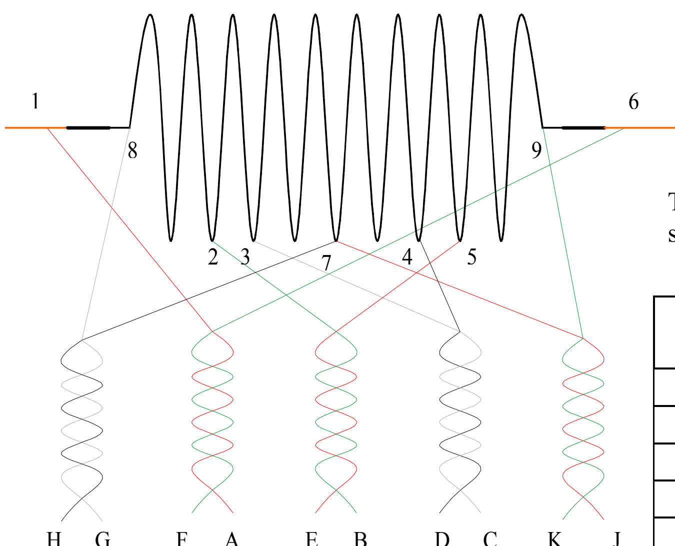


Fig.4 Taps and wiring configuration for spike studies

Tab.2 Taps and wiring configuration for voltage spike studies.

CABLE WIRE	CONN. 12-PIN	PROBE WIRE	TAPS LOCATION
RED	A	RED	1
GREEN	B	GREEN	2
BLUE	C	WHITE	3
BLACK	D	BLACK	4
BLACK	E	RED	5
BLACK	F	GREEN	6
YELLOW	G	WHITE	8
BLACK	H	BLACK	7
BROWN	J	RED	7
BLACK	K	GREEN	9
WHITE	L	WHITE	SPARE
BLACK	M	BLACK	SPARE

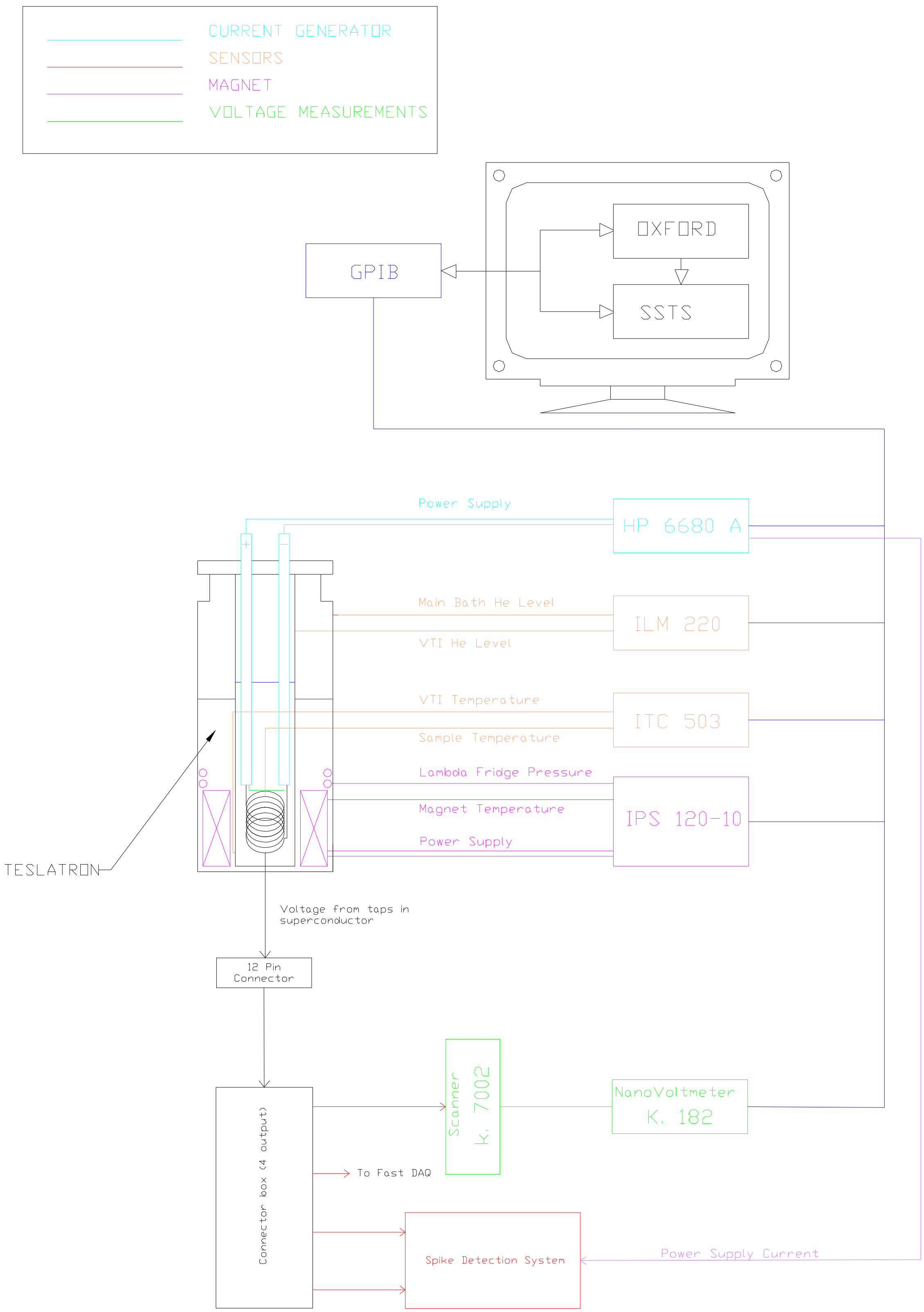


Fig.5 Simplified electric schematic of the SSTF after the introduction of the connector box

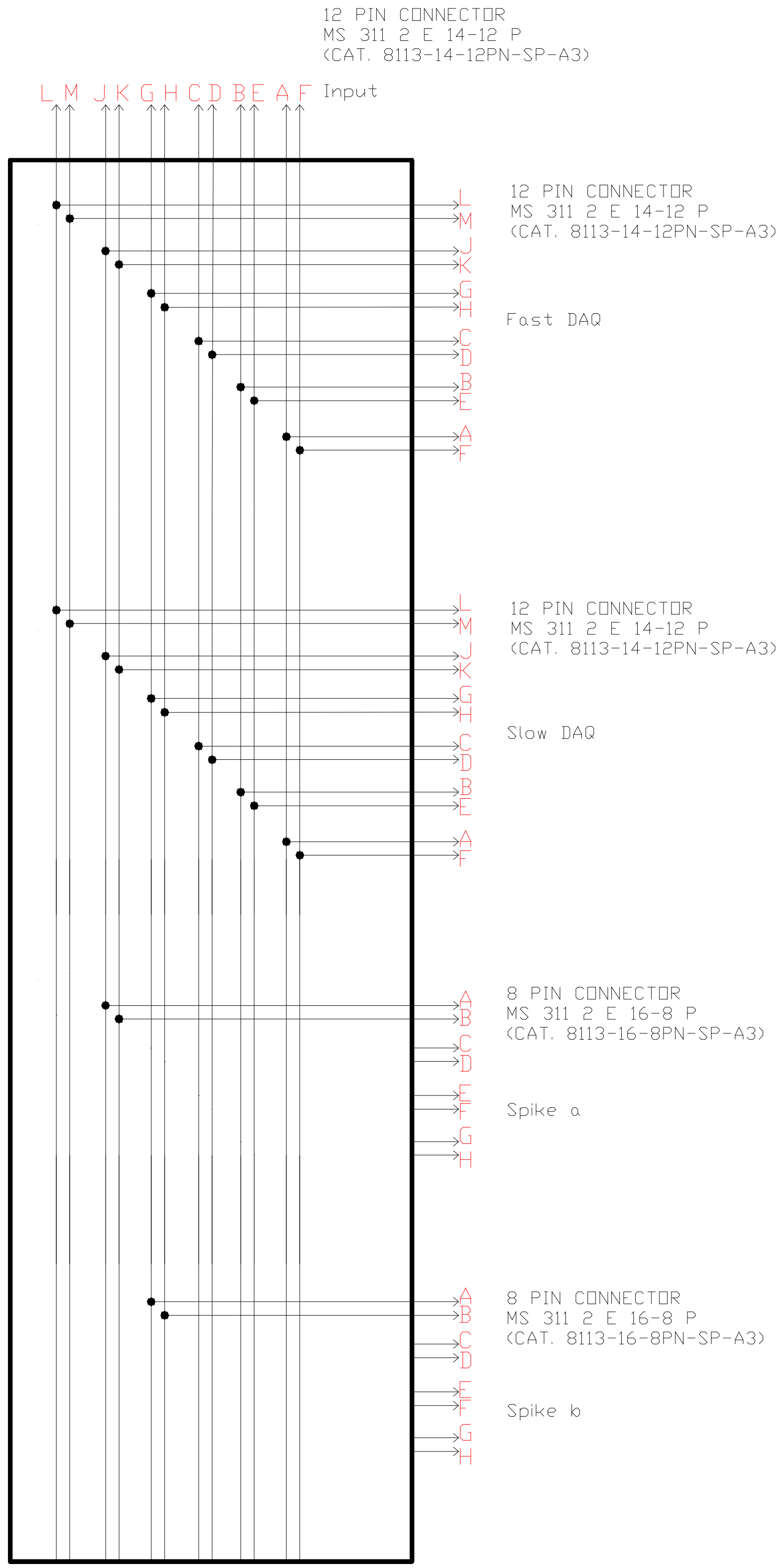


Fig.6 Electric schematic of the connector box that split the signals

2.4) Voltage Spike Detection System

The input signal is first conditioned by a low pass filter, which attenuates frequencies greater than 30 KHz and also blocks RF noise to the preamplifier preventing harmonic distortion and rectification of the signal.

The input differential pre-amplifiers provide the major amplification of the signal. The gain can be 5 or 21 and it is jumper selectable (without jumpers the gain is 5). For spikes studies using strands the gain will be 21. These amplifiers were placed upstream of the fast isolation amplifiers in order to increase the signal magnitude before isolation, therefore improving the signal to noise ratio (SNR).

The isolation amplifier component chosen for this circuit is the Analog Devices AD215. It has a 1500V isolation voltage rating, a wide bandwidth of 120 KHz, and a low harmonic distortion of -80dB. A second filter at the output of the isolation amplifiers filters out high frequency modulation noise produced by the isolation amplifiers – typically ~2.5mVpp (peak-to-peak voltage). Together with the input filter, this forms a 2^{nd} order low pass filter for the input signal.

The signal-conditioning board (SCB) is commercially available from National Instruments, SCB-68, and its output is digitized by the National Instruments PXI multifunction DAQ: NI PXI-6120, fig.7. This module has 4 channels of simultaneous Analog to Digital Converters (ADC), 2 channels of Digital to Analog Converters (DAC), 8 channels of input/output (I/O), and 2 counter/timers. The ADC has 16-bit resolution, built-in anti-aliasing filters, and can sample up to 800 KHz. The maximum voltage input is ±42V.

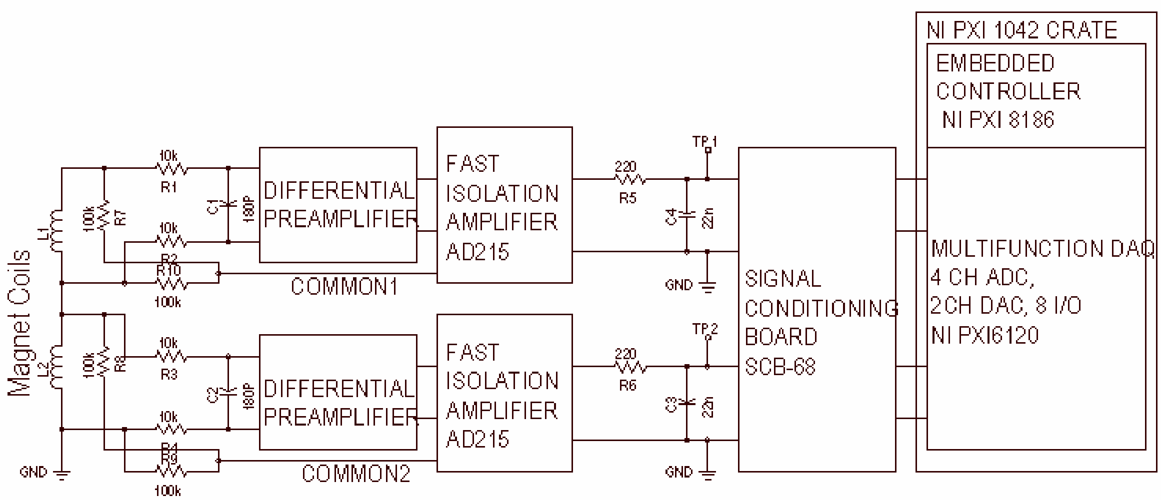


Fig.7 Voltage transient "Spike" detection circuit block diagram

2.5) Ramp rate control

At the SSTF during critical current measurements the current ramp is not continuous, it is close to a step function. Frequency of the steps is ~1.5 sec which generates a fast ~10^{-2} *sec* sudden increase of the current. These current steps generate inductive voltages in the coil and that would interfere with spike measurements. With steps of 20A the inductive voltage peak in the coil is about 2 mV. This value is unacceptable since we expect to measure voltage spikes of the order of 1 mV. Moreover this fast change in current is defeating the purpose of these measurements: studying the strands in conditions as much similar as possible to those of magnets. For this reasons Dan Turrioni, the electronic engineer of the SSTF, developed a faster current control system that allows updating the current value in every 2 ms instead of ~ 1.5 sec and achieving a significant reduction of the amplitude of the current steps.

2.6) Coil inductance estimate and measurements

In this section the inductance and the inductive signal due to current steps is evaluated. The coil inductance is estimated based on the geometry shown in fig. 1. Using an infinite coil approximation the inductance is:

$$L = \mu_0 \cdot n^2 \cdot l \cdot A \qquad 1)$$

- n = number of turns per length unity;
- l = length of the coil;
- A = area of the coil.

Expressing eq.1 as a function of the total number of turns, N and the diameter of the coil d :

$$L = 4\pi \cdot 10^{-7}\left(\frac{N}{l}\right)^2 \cdot l \cdot \frac{\pi d^2}{4} = \pi^2 \cdot 10^{-7} N^2 \frac{d^2}{l}$$

Since:

d = 3.2 *cm*,
coil step =0.3175 *cm*
N=10;

the estimated value of the inductance is:

$$L(\mu H) = \pi^2 \cdot 10^{-1} N^2 \frac{d^2(cm)}{l(cm)} 10^{-2} \qquad L(\mu H) = \pi^2 \cdot 10^{-1} 10^2 \frac{10.24}{3.175} 10^{-2} = 3.18$$

This calculation is an overestimate because it is related to an infinite coil, a reasonable correction factor, for the ratio of d/l is about 0.7; using this factor the inductance estimate becomes 2.2*μH*.

Measuring the resistance and the inductance of 10 turns with a LCR meter we got:

100 *Hz* ➔ L= 2.5 μH
1 *kHz* ➔ L= 2.37 μH
10 *kHz* ➔ L= 2.445 μH $R = 38.35\ m\Omega$

Assuming an inductance of 2.4 μH, a current step of 20A with a rise time of $2 \cdot 10^{-2}$ *sec*, we can estimate that the ramp rate during the step is approximately 1000 A/sec and the inductive voltage is of the order of 2.4 mV.

3) Software for spikes detection

Current-voltage measurements will be performed with the standard SSTF system while for voltage spike detection a stand alone program implemented in the spike detection hardware will be used. The control software for this system is written in Labview, and runs under the National Instruments real-time environment of the PXI controller. The main purpose of this software is to perform filtering, digital bucking, and triggering for data storage along with pseudo real-time visualization of the data with FFT of the bucked half-coils signal [2].

4) Sample to test

In tab. 3 the samples that have been heat treated for spikes studies are listed.

Tab.3 Nb_3Sn strands reacted for spike studies

Sample #	SC	Technology	HT	Diam. mm	D_{eff} µm	Barrel	Billet #
1A	Nb_3Sn	MJR	OST	1	110	Ti	218-3A
1B	Nb_3Sn	MJR	OST	1	110	Ti	218-3A
2A	Nb_3Sn	MJR	OST	0.7	80	Ti	208A
2B	Nb_3Sn	MJR	OST	0.7	80	Ti	208A
3A	Nb_3Sn	MJR	72h 650 °C	1	110	Ti	218-3A
3B	Nb_3Sn	MJR	72h 650 °C	1	110	Ti	218-3A
4A	Nb_3Sn	MJR	72h 650 °C	0.7	80	Ti	208A
4B	Nb_3Sn	MJR	72h 650 °C	0.7	80	Ti	208A
5A	Nb_3Sn	PIT	SMI	0.7	35	Ti	176B
5B	Nb_3Sn	PIT	SMI	0.7	35	Ti	176B

The standard Oxford heat treatment (OST HT) is : 25 *°C/hr* to 210 *°C,* 100 *hr,* 50 *°C/hr* to 340 *°C,* 48 *hr,* 75 *°C/hr* to 650 *°C,* 180 *hr* ➔ 14.6 days.
Samples #3 & 4 had the first part of the heat treatment equal to the standard OST HT but they were removed from the oven after 72 *hr* at 650 *°C.*

- Sample #1 & 3:
  - are the strands with the biggest filament size; in these samples we should observe the highest voltage spikes
  - the heat treatment used for #1 is the same as what was used for cos-theta dipoles (RRR~5) and it is expected to have a low RRR
  - the heat treatment used for #3 is the same as what was used for the Small Racetrack SR02 (RRR~120) and it is expected to have a high RRR

- Sample #2 & 4:
  - have the same geometry and technology as Sample #1 & 3 but they have smaller filament sizes ~80 μm instead of 110 μm
  - Since the area of these strands is ½ as much as the area of the 1mm strands we will not expect to be limited by the power supply output current capability at low magnetic fields.
- Sample #5 should have as good RRR value as sample #4 but a filament size much smaller ~35 μm instead of 80 μm

5) Test procedure

1) <u>Critical current measurements: ramp up the current with a constant magnetic field. The measurements have to be performed from 15T down to the lowest magnetic field value where it is possible to observe a reversible transition from the superconducting to the normal state. The magnetic field step between each measurement is not bigger than 1T.</u>

- Ramp the magnet field at 1 T/min up to 12 T then ramp at 0.5 T/min up to 15 T
- Ramp up the current at 20 A/sec until quench occurs (I_{q15}) (1mm MJR→400 A @ 15 T).
- At 15*T* ramp the current at 20 *A/sec* up to I_{q15} -20% then at 1 A/sec up to quench
- At lower magnetic field ramp the current at 20 A/sec up to the critical current value reached during the previous test performed at higher magnetic field value and than at 1 *A/sec* up to quench.
- At the field (B_d) where we do not see a reversible transition, repeat the measurement at least 3 times.

Assuming to follow this procedure down to 8T, it takes about two hours.

2) <u>Quench current measurements of strongly magnetized strands: sweep the magnetic field with a constant current (sweeping field test).</u>

- Ramp the magnet field down to 0T at 1T/min
- Ramp the current (ramp rate 20 A/sec) up to quench (I_{q0}) in order to remove strand preconditioning
- Sweep the magnetic field up from 0 to 4 T at 1T/min with a current ~ 20% lower than I_{q0};
- Repeat the sweeping field test between 0 and 4T with progressively lower currents (reduce the current by ~10% I_{q0}) till reaching the minimum quench

current I_{qMin}. Always remove preconditioning before each sweeping field test. At the current where the strand can not be quenched sweeping the field between 0 and 4 T, repeat the experiment at least 2 times. (Assuming I_{q0}=1000A and I_{qMin}=600A the sweeping test will be performed once at 800A, 700A, 600A and twice at 500A)

This experiment is expected to take about 3 hours.

3) Quench current measurements of demagnetized strands: ramp the current with a fixed magnetic field starting with a sample completely demagnetized. The magnetic field step between each measurement is 1T.

- Ramp the magnetic field down to 0T at 1T/min
- Quench the strand in order to remove strand preconditioning (ramp rate 20 A/sec)
- At 0 T ramp the current at 20 *A/sec* up to $0.9 \cdot I_{q0}$ then at 1 *A/sec* up to quench.
- At 1T ramp the current at 20 *A/sec* up to quench I_{q1} ;
- At 1 T ramp the current at 20 *A/sec* up to $0.9 \cdot I_{q1}$ then at 1 *A/sec* up to quench.
- Repeat the former two steps at higher magnetic fields where the quench current is lower than the critical current.

This experiment is expected to take about 3 hours.

References

[1] L. F. Goodrich *et al.*, "Superconductor critical current standards for fusion application", *NISTIR 5027, NIST.*

[2] D. F. Orris *et al.*, "Voltage spike detection in high field superconducting accelerator magnets", *IEEE Trans. Appl. Superconduct.*, vol 15, no.2 , pp 1205 – 1208

[3] E. Barzi *et al.*, "Short sample J_c measurements at the Short Sample Test Facility", *Fermilab technical note*, TD-98-057

[4] D. Turrioni *et al.*, "A fast DAQ Solution for Transformer Test at the SSTF", *Fermilab technical note*, TD-04-011

Appendix

PT, SP, MS/PT
how to order

PT, SP

To more easily illustrate ordering procedure, part number PT00A-20-41PW(SR) is shown as follows:

PT	00	A	-	20	-	41	P	W	(SR)
1	2	3		4		5	6	7	8

See code below:

1. Connector Type
   "PT" designates standard olive drab, electrically conductive cadmium plated bayonet lock connector with solder contacts
   "SP" designates electrically non-conductive, hard anodic coated bayonet lock connector with solder contacts and larger flange and mounting holes for back panel mounting
   "PTG" designates plug with grounding fingers
2. Shell Style
   "00" designates wall mounting receptacle
   "01" designates cable connecting receptacle**
   "02" designates box mounting receptacle
   "06" designates straight plug
   "07" designates jam nut receptacle
   "08" designates 90 degree plug cable support
   "B" designates thru bulkhead receptacle (pressurized)
   "I" designates solder mount receptacle (Hermetic only)
3. Service Classes
   "A" designates general duty back shell
   "C" designates pressurized receptacle
   "E" designates environmental resisting open wire seal with grommet and nut
   "J" designates clamp assembly for moisture proofing multi-jacketed cables, with strain relief
   "P" designates assembly with potting boot
   "W" designates clamp assembly for moisture proofing multi-jacketed cables
   "H" designates hermetic* without interfacial seal
   "Y" designates hermetic* with interfacial seal
4. Shell Size
   "20" designates shell size. Shell sizes 6 through 24 available.
5. Insert Arrangement
   "20 - 41" designates insert arrangement. Refer to pages 56-61 for insert availability.
6. Contacts
   "P" designates pin contacts
   "S" designates socket contacts
   For ordering connectors with printed circuit board contacts, see pg. 12.
7. Insert Rotation
   "W", "X", "Y", "Z" designate that insert is rotated in its shell from "normal position. No letter required for normal (no rotation) position.
8. "SR" designates a strain relief clamp.
   Indicate optional finishes as follows:
   (003) olive drab cadmium plate (standard on "PT")
   (005) anodic coating - Alumilite® (standard on "SP")
   (014) olive drab cadmium plate over nickel
   (023) electroless nickel
   (024) olive drab zinc cobalt plating
   (025) non-conductive black zinc cobalt plating
   (027) conductive black zinc cobalt plating
   (424) electroless nickel finish with strain relief
   (466) olive drab zinc cobalt plating with strain relief
   (470) non-conductive black zinc cobalt plating with strain relief
   (476) conductive black zinc cobalt plating with strain relief
   (100) Suffix added for flat eyelet pin contacts in hermetic versions

MS/PT
MIL-C-26482, Series 1

Part number MS3110E20-41PW is shown as follows:

MS	311	0	E	20	-	41	P	W
1	2	3	4	5		6	7	8

For Hermetic connectors part number MS3113H20Y41PW is shown as follows:

MS	311	3	H	20 Y 41	P	W
1	2	3	4	5, 6	7	8

See code below:

1. "MS" designates Military Standard
2. Specification Number
   "311" designates basic family number for MIL-C-26482, Series 1 solder type
3. Shell Style
   "0" designates wall mounting receptacle
   "1" designates cable connecting receptacle**
   "2" designates box mounting receptacle
   "3" designates solder mount receptacle (hermetic only)
   "4" designates jam nut receptacle
   "6" designates straight plug
4. Service Class
   "E" designates environmental resisting connector
   "F" designates environmental resisting connectors with strain relief
   "J" designates clamp assembly for moisture proofing multi-jacketed cables, with strain relief
   "P" designates potted type with potting boot
   "H" designates hermetic
5. Shell Size
   "20" designates shell size. Shell sizes 8 through 24 available.
6. Insert Arrangement
   "20-41" designates arrangement. Refer to pages 56-61 for insert availability.
   Hermetic version
   "20Y41" designates insert arrangement; specify "Y" for flat eyelet pin contacts, or "C" for solder cup pin contacts
7. Contact Configuration
   "P" designates pin contacts
   "S" designates socket contacts
8. Insert Rotation
   "W", "X", "Y", "Z" designate that insert is rotated in its shell from "normal" position. No letter required for normal (no rotation) position.

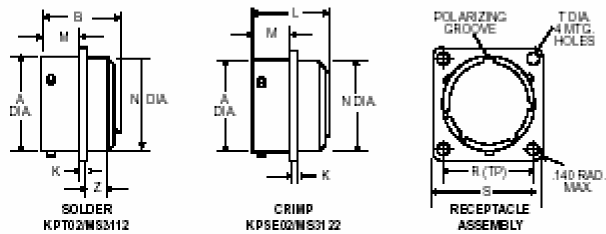
* Hermetic connectors are supplied with tin plated shells.

** This connector style is sometimes referred to as a cable connecting "plug". It does, however, mate with either a straight or 90 degree plug.

18

Box Mounting Receptacles

MS3112 **KPT02**
(MS service class E)
MS3122 **KPSE02**
(MS service class E)



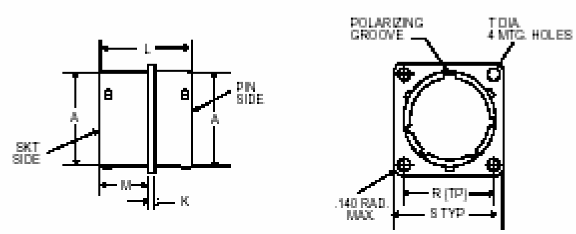
Note: Connector does not accommodate backshell.

Shell Size	A ± .003 (±.08)	B Max	K ± .016 (±.41)	L Max.	M + .031 (+.79) -.000 (-.00)	N Dia. Max.	R* (TP)	S Max.	T ± .005	Z Max.
†8	.471 (11.96)	.978 (12.14)	.062 (1.57)	1.320 (33.07)	.431 (10.95)	.469 (11.91)	.594 (15.09)	.828 (21.03)	.120 (3.05)	.354 (8.99)
10	.588 (14.96)	.978 (12.14)	.062 (1.57)	1.320 (33.07)	.431 (10.95)	.593 (15.06)	.719 (18.26)	.954 (24.23)	.120 (3.05)	.354 (8.99)
12	.748 (19.00)	.978 (12.14)	.062 (1.57)	1.320 (33.07)	.431 (10.95)	.719 (18.26)	.812 (20.62)	1.047 (26.59)	.120 (3.05)	.354 (8.99)
14	.873 (22.17)	.978 (12.14)	.062 (1.57)	1.320 (33.07)	.431 (10.95)	.843 (21.41)	.906 (23.01)	1.141 (28.98)	.120 (3.05)	.354 (8.99)
16	.998 (25.35)	.978 (12.14)	.062 (1.57)	1.320 (33.07)	.431 (10.95)	.969 (24.61)	.969 (24.61)	1.234 (31.34)	.120 (3.05)	.354 (8.99)
18	1.123 (28.52)	.978 (12.14)	.062 (1.57)	1.320 (33.07)	.431 (10.95)	1.093 (27.76)	1.062 (26.97)	1.328 (33.73)	.120 (3.05)	.354 (8.99)
20	1.248 (31.70)	1.196 (30.38)	.094 (2.39)	1.367 (34.72)	.556 (14.12)	1.219 (30.96)	1.156 (29.36)	1.453 (36.91)	.120 (3.05)	.417 (10.59)
22	1.373 (34.87)	1.196 (30.38)	.094 (2.39)	1.367 (34.72)	.556 (14.12)	1.343 (34.11)	1.250 (31.75)	1.578 (40.08)	.120 (3.05)	.417 (10.59)
24	1.498 (38.05)	1.196 (30.98)	.094 (2.39)	1.418 (36.02)	.589 (14.96)	1.469 (37.31)	1.375 (34.92)	1.703 (43.26)	.147 (3.73)	.445 (11.30)

†Not available in KPSE. *(TP) located within .010T.P. with respect to diameter A and master keyway.

Thru-Bulkhead Receptacles

MS3119 **KPTB**
(MS service class E)

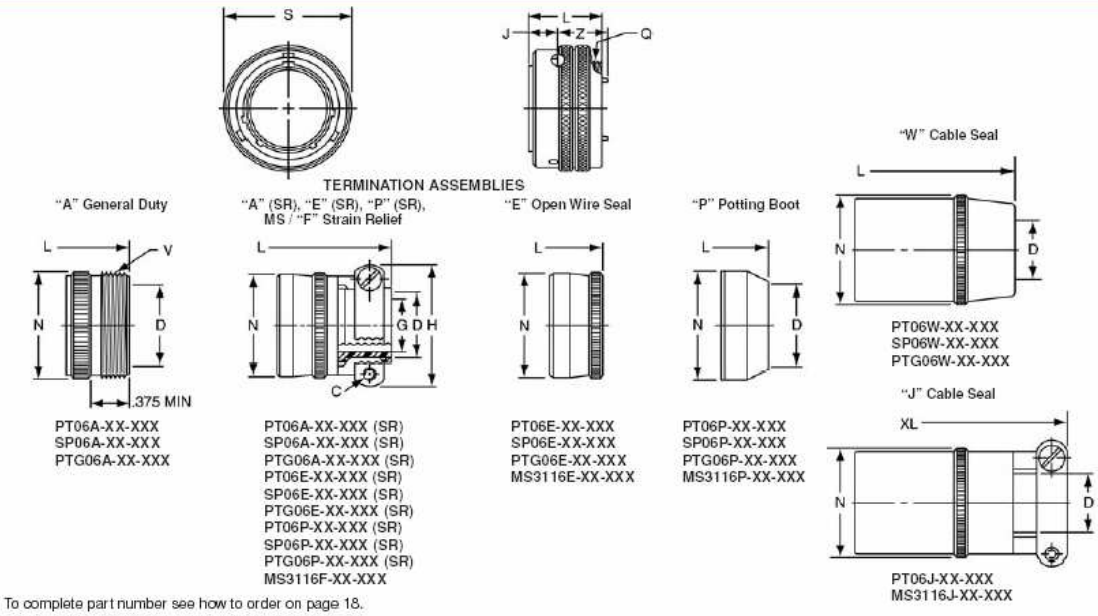


*(T.P.) located within .010 T.P. with respect to diameter A and master keyway.

Shell Size	A Dia. ± .003 (±.08)	K ± .016 (±.406)	L Max.	M + .031 (+.79) -.000 (-.00)	R* (TP)	S Max.	T ± .005 (± .127)
†8	.471 (11.96)	.062 (1.57)	1.125 (28.58)	.562 (14.27)	.594 (15.09)	.828 (21.03)	.120 (3.05)
10	.588 (14.94)	.062 (1.57)	1.125 (28.58)	.562 (14.27)	.719 (18.26)	.954 (24.23)	.120 (3.05)
12	.748 (19.00)	.062 (1.57)	1.125 (28.58)	.562 (14.27)	.812 (20.62)	1.047 (26.59)	.120 (3.05)
14	.873 (22.17)	.062 (1.57)	1.125 (28.58)	.562 (14.27)	.906 (23.01)	1.141 (28.98)	.120 (3.05)
16	.998 (25.35)	.062 (1.57)	1.125 (28.58)	.562 (14.27)	.969 (24.61)	1.234 (31.34)	.120 (3.05)
18	1.123 (28.52)	.062 (1.57)	1.125 (28.58)	.562 (14.27)	1.062 (26.97)	1.328 (33.73)	.120 (3.05)
20	1.248 (31.70)	.094 (2.39)	1.406 (35.71)	.688 (17.48)	1.156 (29.36)	1.453 (36.91)	.120 (3.05)
22	1.373 (34.87)	.094 (2.39)	1.406 (35.71)	.688 (17.48)	1.250 (31.76)	1.578 (40.08)	.120 (3.05)
24	1.498 (38.05)	.094 (2.39)	1.406 (35.71)	.688 (17.48)	1.375 (34.92)	1.703 (43.26)	.147 (3.73)

Performance Specifications - Page 142
Contacts, Sealing Plugs, Assembly Tools - Page 154
Contact Arrangements - Page 149

PT06 (MS3116)
SP06
straight plug



To complete part number see how to order on page 18.

Shell Size	Plug Front View	Plug Side View				Class "A"			
	S Max.	J	L Max.	Q Thread Class 2A	Z Max.	D Min.	L Max.	N Max.	V Thread Class A
6	.625	.353	.906	.3125-32 NEF	.594	.175	1.609	.462	.3750-32 NEF
8	.750	.353	.906	.4375-28 UNEF	.594	.297	1.609	.590	.5000-28 UNEF
10	.859	.353	.906	.5625-24 NEF	.594	.421	1.609	.717	.6250-24 NEF
12	1.013	.353	.906	.6875-24 NEF	.594	.546	1.609	.834	.7500-20 UNEF
14	1.156	.353	.906	.8125-20 UNEF	.594	.663	1.609	.970	.8750-20 UNEF
16	1.281	.353	.906	.9375-20 UNEF	.594	.787	1.609	1.088	1.0000-20 UNEF
18	1.319	.353	.906	1.0625-18 NEF	.594	.879	1.609	1.216	1.1875-18 NEF
20	1.531	.415	1.062	1.1875-18 NEF	.672	1.014	1.656	1.332	1.1875-18 NEF
22	1.656	.415	1.062	1.3125-18 NEF	.672	1.135	1.656	1.460	1.4375-18 NEF
24*	1.776	.415	1.125	1.4375-18 NEF	.672	1.259	1.750	1.587	1.4375-18 NEF

Shell Size	Class "A" (SR), "E" (SR), "P" (SR), MS / "F"						Class "E", MS / "E"		Class "P", MS / "P"			Class "W", "J"				
	C Thread	D Min.	G ±.010	H Max.	L Max.	N Max.	L Max.	N Max.	D Min.	L Max.	N Max.	D Closed	D Free	L Max.	N Max.	XL Max.
6	–	–	–	–	–	–	1.266	.440	.192	1.526	.484	–	–	–	–	–
8	6-32	.240	.125	.812	1.906	.550	1.266	.560	.317	1.526	.608	.168	.230	1.705	.547	2.271
10	6-32	.302	.188	.875	1.906	.675	1.266	.685	.434	1.526	.734	.205	.312	1.705	.675	2.271
12	6-32	.428	.312	1.000	1.906	.803	1.266	.813	.548	1.526	.858	.338	.442	1.848	.812	2.411
14	6-32	.552	.375	1.125	1.906	.920	1.266	.930	.673	1.526	.984	.416	.539	2.040	.940	2.599
16	6-32	.615	.500	1.188	2.047	1.047	1.266	1.057	.798	1.526	1.110	.550	.616	2.256	1.067	2.943
18	8-32	.740	.625	1.438	2.078	1.165	1.266	1.175	.899	1.526	1.234	.600	.672	2.486	1.194	3.172
20	8-32	.740	.625	1.438	2.250	1.290	1.438	1.301	1.024	1.546	1.360	.635	.747	2.844	1.322	3.610
22	8-32	.928	.750	1.625	2.250	1.418	1.438	1.430	1.149	1.546	1.484	.670	.846	3.000	1.449	3.766
24*	8-32	.990	.800	1.750	2.312	1.543	1.500	1.555	1.274	1.656	1.610	.740	.894	3.210	1.576	3.985

* Available in PT06 only
All dimensions for reference only.

PT-SE, SP-SE, MS/PT-SE
how to order

PT-SE, SP-SE

To more easily illustrate ordering procedure, part number PT00SE-20-41PW(SR) is shown as follows:

PT	00	SE -	20 -	41	P	W	(SR)
1	2	3	4	5	6	7	8

See code below:

1. Connector Type
   "PT" designates standard olive drab, electrically conductive cadmium plated, bayonet lock connector
   "MF" designates standard olive drab, electrically conductive cadmium plated, bayonet lock connector with dual mounting holes
   "SP" designates electrically non-conductive, hard anodic coated, bayonet lock connector with larger flange and mounting holes for back panel mounting
   "PTG" designates plug with grounding fingers
2. Shell Style
   "00" designates wall mounting receptacle
   "01" designates cable connecting receptacle*
   "02" designates box mounting receptacle
   "06" designates straight plug
   "07" designates jam nut receptacle
   "08" designates 90 degree plug
3. Service Classes
   "SE" designates environmental crimp
   "SP" designates potted type crimp
   Both of the above are Amphenol proprietary versions of the MIL-C-26482, Series 1 crimp contact connector and offer 15 lbs. contact retention for size 20 contacts; 25 lbs. for size 16 contacts.
4. Shell Size
   "20" designates shell size. Shell sizes 8 through 24 available.
5. Insert Arrangement
   "20 - 41" designates insert arrangement. Refer to pages 56-61 for insert availability.
6. Contacts
   "P" designates pin contacts
   "S" designates socket contacts
7. Insert Rotation
   "W", "X", "Y", "Z" designate that insert is rotated in its shell from "normal" position. No letter required for normal (no rotation) position.
8. "SR" designates a strain relief clamp.
   Indicate optional finishes as follows:
   (003) olive drab cadmium plate (standard on "PT")
   (005) anodic coating - Alumilite® (standard on "SP")
   (014) olive drab cadmium plate over nickel
   (023) electroless nickel
   (024) olive drab zinc cobalt plating
   (025) non-conductive black zinc cobalt plating
   (027) conductive black zinc cobalt plating
   (424) electroless nickel finish with strain relief
   (466) olive drab zinc cobalt plating with strain relief
   (470) non-conductive black zinc cobalt plating with strain relief
   (476) conductive black zinc cobalt with strain relief

MS/PT-SE
MIL-C-26482, Series 1

To more easily illustrate ordering procedure, part number MS3120E20-41PW is shown as follows:

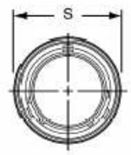
MS	312	0	E	20 –	41	P	W
1	2	3	4	5	6	7	8

See code below:

1. "MS" designates Military Standard
2. Specification Number
   "312" designates basic family for MIL-C-26482, Series 1 crimp type
3. Shell Style
   "0" designates wall mounting receptacle
   "1" designates cable connecting receptacle*
   "2" designates box mounting receptacle
   "4" designates jam nut receptacle
   "6" designates straight plug
   "7" designates box mounting receptacle with dual mounting holes
   "8" designates wall mounting receptacle with dual mounting holes
4. Service Class
   "E" designates environmental resisting connector
   "F" designates environmental resisting connector with strain relief
   "P" designates potted type with potting boot
5. Shell Size
   "20" designates shell size. Shell sizes 8 through 24 available
6. Insert Arrangement
   "20 - 41" designates insert arrangement. Refer to pages 56-61 for insert availability.
7. Contacts
   "P" designates pin contacts
   "S" designates socket contacts
8. Insert Rotation
   "W", "X", "Y", "Z" designate that insert is rotated in its shell from the "normal" position. No letter required for normal (no rotation) position.

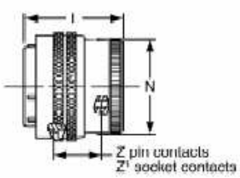
* This connector style is sometimes referred to as a cable connecting "plug". It does, however, mate with either a straight or 90 degree plug.

PT06 SE (MS3126)
SP06 SE
straight plug



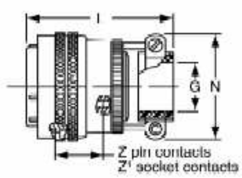
TERMINATION ASSEMBLIES

"SE", MS / "E" Open Wire Seal



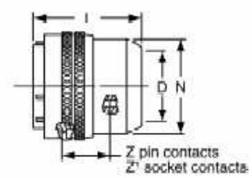
PT06SE-XX-XXX
SP06SE-XX-XXX
PTG06SE-XX-XXX
MS3126E-XX-XXX

"SE" (SR), MS / "F" Strain Relief



PT06SE-XX-XXX (SR)
SP06SE-XX-XXX (SR)
PTG06SE-XX-XXX (SR)
MS3126F-XX-XXX (SR)

"SP", MS / "P" Potting Boot



PT06SP-XX-XXX
SP06SP-XX-XXX
PTG06SP-XX-XXX
MS3126P-XX-XXX

To complete part number see how to order on page 30.

	Plug Front View	Plug Side View										
				Class "SE", MS / "E"		Class "SE" (SR), MS / "F"			Class "SP", MS / "P"		
Shell Size	S Dia. Max.	Z ±.045	Z^1 ±.045	L Max.	N Max.	G Dia.	L Max.	N Max.	D Dia.	L Max.	N Dia. Max.
8*	.734	.640	.579	1.328	.540	.125	2.413	.828	.327	1.750	.578
10	.859	.640	.579	1.328	.685	.188	2.413	.891	.444	1.750	.734
12	1.031	.640	.579	1.328	.813	.312	2.413	1.016	.558	1.750	.858
14	1.156	.640	.579	1.328	.930	.375	2.413	1.141	.683	1.750	.984
16	1.281	.640	.579	1.328	1.057	.500	2.528	1.203	.808	1.750	1.110
18	1.391	.640	.579	1.328	1.175	.625	2.528	1.469	.909	1.750	1.234
20	1.531	.640	.579	1.297	1.301	.625	2.753	1.469	1.034	1.750	1.360
22	1.656	.640	.579	1.297	1.428	.750	2.753	1.656	1.159	1.750	1.484
24	1.777	.640	.579	1.359	1.533	.800	2.830	1.750	1.284	1.766	1.610

* PT-SE, MS-SE and MS-SP only.

All dimensions for reference only.